MCZ newsletter
MUSEUM OF COMPARATIVE ZOOLOGY

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Understanding Nature in the MCZ

"Understanding Nature" is a university wide series of exhibitions that opened December 11 in honor of the centennial of the American Society of Zoologists, whose president this year is the MCZ's Henry Bryant Bigelow Professor Karel F. Liem. The exhibitions will highlight the work of early American naturalists. One of the most eminent of these pioneers is Alexander Wilson. A 19th century ornithologist, Wilson is best known for his triumph of early American science and printing, *American Ornithology: or the Natural History of the Birds of the United States.* This inspiring series of nine volumes published between 1808 and 1814 catalogs the birds of North America. Each bird in the volume is described in elegant prose and painstakingly illustrated with hand-colored engravings. Only a person possessing Wilson's tenacity and skill could have persevered in the self-imposed task of collecting and mounting birds, and describing and painting them with such scientific integrity. Many of these birds were described by Wilson for the first time and are type specimens (the specimen on which the first description of the species is based).

Plates from Alexander Wilson's American Ornithology, *1808-1814.*

American Ornithology will be on display in the MCZ Library. The MCZ Special Exhibition Gallery will present some of Wilson's original paintings paired with the specimens from which they were drawn. These specimens are thought to be the oldest preserved vertebrates in North America and number amongst the most historically valuable in the MCZ. Memorabilia of Wilson's life as a zoologist will also be shown. Companion exhibitions will be mounted in the Fogg Museum and the Widener, Houghton and Pusey Libraries.

Patterns Of a Life In Science: C. Richard Taylor

by Hilary Hopkins

" What is it about doing field work that appeals to you the most?" I asked Professor C. Richard Taylor, Director of the Concord Field Station of the MCZ, and Alexander Agassiz Professor Of Zoology. "What is the most fun?"

"Oh, being outside," he answered, "and actually being able to look at animals, and see how they're able to solve the problems of living in extreme environments. And encountering extreme environments yourself.

I get a certain exhilaration, being in a hot desert," he added.

"What are you best at, as a scientist, do you think?"

He paused to reflect. "I think the strength of our laboratory is in obtaining data under conditions that are controlled enough to mimic what animals actually encounter in different situations. Sometimes that's involved using very unusual animals—you have to not be put off by having pythons in the lab, for instance. And I've able to work with some of the African animals, which turns out not to be so easy. Trying to get animals to run on the treadmills for you—"

"I like to pursue something until I get an answer that satisfies me. If you look at it, I've only pursued three or four questions over the last twenty-five years or so, but I really want to be able to understand them, I guess it's persistence, stubbornness maybe—not giving up."

He ticked off a list of wonderful questions: "How much energy does it take to move around in Nature? Are animals specialized to move around cheaply, and how important is it to move around cheaply? How fast can animals go, and what really determines that?"

Earlier we had been speaking of his childhood interests. He explained, "I grew up in South-

gate, right next to Watts, in Los Angeles, and at that time there were farms all around the city, so I picked beans and corn, and helped out during the harvesting seasons and I enjoyed going to the beach, and hiking in the mountains."

Professor Taylor's interest in animal mechanics and locomotion turns out to have begun early; I asked if he recalled any special outdoor events during his childhood. "Well," he responded, "I remember hiking along and seeing a tarantula by the side of the trail. I watched it move, very quickly, which seemed startling, and I remember wondering how it was able to coordinate all those legs and move so agilely. That was probably when I was six or seven."

We spoke further of his childhood. "My father was a minister. He was very active politically, in the American Civil Liberties Union and other rights organizations. One of the first things I remember—of course I was very tiny—was when my father took us down to see the Japanese being interned— the idea that this was in fact something that could go on in this country. We always had a very interesting group of people to Sunday dinner—from Alcoholics Anonymous and convict rehabilitation groups and so on."

"When I started college I thought I would go into medicine, or law, or some sort of government service. Our family felt that there was an obligation to serve society, and I thought that in those fields you could do things for others."

Needing to take a physiology course for a possible concentration in medicine, Taylor discovered the joys of field work. "The guy who taught the course was working on the desert animals, so we were doing work in the Mojave Desert, and Arizona, and Baja California. I became enthralled with it. I got particularly interested in birds and how they drink sea water and whether they had special kidneys to handle that, and I wrote a paper about it."

But the family ethos persisted. "For my undergraduate interdepartmental honors thesis, I wrote about the biological effects of ionizing radiation, and how much politicians knew about that, and what they did with the information. That was at a time when you still had above-ground tests, that you could go out and watch from the front yard. In LA they'd tell you, 'Hold this film over your eyes' "—he gestures—" and 'watch it go up.' In fact you were

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Hilary Hopkins, a Friend of the MCZ since 1981, is a science enthusiast and educational consultant specializing in gifted children. This article is the seventh of a series she has prepared for the MCZ Newsletter.

Mutualism in the Rain Forest

MCZ graduate student in behavioral ecology Dan Perlman spends most of his time in Monte Verde, Costa Rica looking very closely at *Cecropia* trees. It is only on these trees that the two species of *Azteca* ants he studies can be found. Perlman is intrigued with the complexities of how Azteca colonies are established within a rich and shifting network of mutualism among the ants and between the ants and plants.

Azteca ants have made their home in *Cecropia* trees for eons, during which time the two organisms have evolved a tight mutualism. The ants protect the tree from constricting vines and insect herbivores; and in return the trees provide the ants with food and shelter. Segmented like bamboo, the hollow sections of the tree make excellent colony nesting places for both young and mature *Azteca* colonies. In addition, the plants produce special food bodies for their congenial guests. The *Cecropia* are one of only two types of plants with the ability to produce glycogen, a substance otherwise only found in animals. In essence the tree manufactures synthetic prey, in the form of this glycogen, for the ants to consume.

Against the background of this ant/plant mutualism is a fiercely competetive situation in which another, and very unusual mutualism appearsthat between species of ants. In order to appreciate the importance of this second mutualism, it is critical to understand the challenges facing a developing *Azteca* colony. While there is only one large ant colony in a mature *Cecropia*, younger trees may have as many as 15 small *Azteca* colonies. Since *Azteca* do not migrate to other trees only the strongest of the original colonies survives.

Painting Queens

Perlman observed developing *Azteca* colonies over a few field seasons, including one of 16 months duration, by cutting small holes in the walls of suitable *Cecropias* and studying the ants using an otoscope (such as a doctor would use to look in an ear) and a fiberoptics endoscope (used for seeing deep inside the human body). Each queen was marked with a paint dot allowing Perlman to follow individual ants over many months in the field. His observations indicated that if a colony is to compete well against its neighbors in the tree, it must quickly develop a large force of workers to gather the tree's limited food supplies. The primary method by which colonies can produce more workers early on is to have more queens than the other colonies, and a way to acquire more queens is mutual cooperation of colonies. The truly remarkable aspect of this system is that the cooperating colonies are often of different species of *Azteca*, making it the only documented case of mutualism between competing species of ants.

Perlman believes that it is the intense competition for control of maturing trees that has made it possible for this unusual mutualism to occur.

Photo by John Sachs.

Dan Perlman closely inspecting one of his study plants in Monteverde, Costa Rica.

Photo by Dan Perlman.

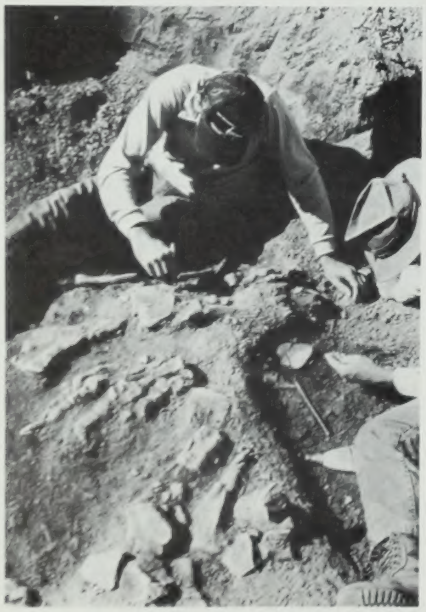
Two views of a spiny katydid

This spring the MCZ will be hosting an exhibition of some of Perlman's closeup photographs from Costa Rica. *Front Yard Photos from Costa Rica: Insects and Flowers Up Close* will open on March 6, 1989. Monteverde proved to be so rich in photographic subjects that nearly all of the photos in the exhibition were shot within the confines of Perlman's own yard.

MCZ field team excavating at prosauropod dinosaur quarry.

Fossils from Greenland

This summer's MCZ fossil finding team returned to the stark terrain of Triassic outcrops in eastern Greenland for a second season in the quest for evidence of early life. Led by Professor Farish A. Jenkins, Jr., expedition members William W. Amaral, and Dr. Stephen M. Gatesy of the MCZ, Dr. Neil H. Shubin from the University of California at Berkeley and H. Edgar Jenkins II returned in jubilant spirits having made several spectacular discoveries of fossil vertebrates that eluded them in the 1988 field season.



Complete hindfoot of dinosaur in situ.

Prior to the first MCZ paleontological expedition in 1988, no fossil vertebrate specimens of substantial scientific significance had ever been recovered from this period of geological time in Greenland.

During the late Triassic (about 200 million years ago), representatives of diverse groups such as mammals, dinosaurs, crocodilians and turtles first appeared; they continued to diversify throughout the remainder of the Mesozoic era. Knowledge of these Late Triassic forms is fundamental to understanding their evolutionary origins.

One of the more spectacular discoveries was an entire prosauropod skeleton representing a primitive herbivorous dinosaur. Among their other finds were various armored reptiles, assorted amphibians (including one giant with skull bones several inches thick) and lung fish.

The prosauropod dinosaur was discovered at a site where a fragmentary vertebrae was found last year, belonging to the genus *Plateosaurus* (similar to the one on exhibit in the MCZ's Romer Hall of Vertebrate Paleontology). It is believed to be the first dinosaur known from Greenland.

The team also returned to the site where in 1988 they had previously found part of a turtle. This year they used screening techniques to recover the remainder of the specimen which had been widely scattered by erosion. It could be a new genus and is an extremely important addition to our knowledge of chelonian evolution which, on present evidence, began during the Late Triassic.

Perhaps the most significant site was one containing a large number of bones of tetrapods (four-legged animals). The unusual abundance and variety of the bones at this locality offer the first possibility of sampling a large fauna.

The expedition was funded by the National Science Foundation's Division of Polar Programs with logistical and technical support from the Polar Ice Core Office (University of Alaska, Fairbanks) and the United States Naval Air Station, Keflink, (Iceland).

Cleaning and removing bones of prosauropod dinosaur pelvis.

Photos courtesy of Farish A. Jenkins, Jr.

Deepsea Tubeworms Update

Not long after tubeworms were found near deepsea hot vents in the late 70s, Assistant Professor of Biology Colleen Cavanaugh postulated that these organisms, some living at depths of 9,000 feet with no digestive tracts, received their nutrition through a symbiotic relationship with bacteria.

Since that time, Cavanaugh as a Harvard graduate student, Junior Fellow, and since July 1 as an assistant professor has pursued that thesis at increasing levels of complexity. The question, in simple terms, is whether the bacteria found in the tissue of deepsea invertebrates such as the tubeworms and certain species of mussels and clams use sulphur the same way plants use sunlight to make nutrients out of inorganic matter.

In this process, known as chemosynthesis, the chemical energy in compounds such as hydrogen sulphide is used to convert carbon dioxide into organic molecules. Thus, chemosynthetic bacterial symbionts could provide the host animal with an internal source of nutrition. Although these types of bacteria were previous known as free-living species, their existence as symbionts was a new discovery.

As a graduate student Cavanaugh used electron microscopy to show that bacteria-like organisms occurred in the tissues of the deepsea tubeworms. The carbon dioxide fixing enzyme was also shown to be present in these bacteria-containing tissues, indicating that chemosynthesis was occurring. She has since shown that similar symbioses appear to be wide spread in nature and have been found in clams, mussels, and benthic worms.

However, one major problem has confronted Cavanaugh over the years in her research: "No one, so far," she says, "has been able to cultivate these bacterial symbionts outside of the host organism. Therefore very little is known about them."

As a result, she has had to resort to other approaches to characterize these symbionts. Using the Atlantic coast clam *Solemya velum* as a model, she has studied the physiology of its bacteria *in situ*, measuring carbon dioxide fixation and what kinds of sulphur compounds stimulate such fixation. She has worked at the

Collen Cavanaugh with a tubeworm.

cellular level, using antibodies to localize the carbon dioxide-fixing enzyme in symbiont containing tissue. And, most recently, Cavanaugh says, "I've been focussing on molecular aspects, sequencing genes from symbionts for comparison with free-living bacteria."

The long term goal of her research is to understand how host and symbiont metabolism are integrated, allowing animals to live in sulphide-rich marine habitats, such as the deepsea vents. How much more work remains? Cavanaugh smiles at the question. "We are still doing the descriptive work," she says.

New Chair for Jenkins

Farish A. Jenkins, Jr., formerly Professor of Biology, has been appointed Alexander Agassiz Professor of Zoology in the MCZ. He is also Professor of Anatomy at Harvard Medical School and Curator of Vertebrate Paleontology in the MCZ.

With this appointment there are now seven Alexander Agassiz Professors at the MCZ including Professors S. J. Gould, B. K. Holldobler, H. W. Levi, R. C. Lewontin, J. J. McCarthy, and C. R. Taylor, made possible by the business acumen and lifelong commitment of Alexander, son of MCZ founder Louis Agassiz, who served as the museum's second director. Following his great success in copper mining, Alexander turned his interests to science, and thus set the stage for the MCZ's role in twentieth-century zoology.

Cambridge Schools Museum Program

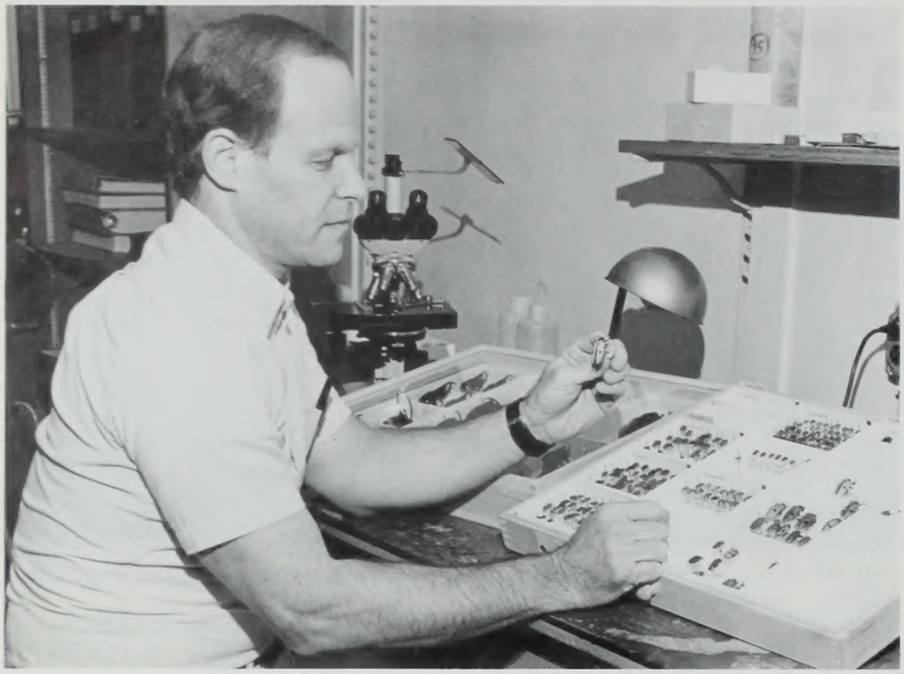
After seven years of a continuous program to third and fourth graders in several Cambridge public schools, lack of funds has made it impossible to continue this year. A combination of factors including the fact that this program is no longer eligible for seed funds from foundations and corporations has contributed to this situation.

Until new support for the program can be found, limited services to Cambridge will continue in the form of a teacher-training program.

It is ironic that a program that has received accolades from principals, parents, teachers, and students as well as being ranked superlative in an independent evaluation conducted by the Harvard Graduate School of Education at the request of John Shattuck, Harvard's Vice President for Government, Community, and Public Affairs, should fall through the cracks of foundation, government, and school system support at a time when the overwhelming need for better science education on all levels is so widely recognized.

Arlene Nichols

New Curatorial Associate is a Beetle Researcher



David Furth

David G. Furth, recently appointed Curatorial Associate in Entomology, is no stranger to the MCZ. Furth, a specialist in chrysomelids (leaf beetles) has "used the collections here for years in my own research."

Furth's research has taken him all over the world on collecting trips. He has worked on beetles in many parts of the United States, in Africa, Central and South America, Europe, and the Middle East, spending six years collecting and doing research in Israel, where he found himself in the middle of the Yom Kippur war of 1973.

He comes to the MCZ at an opportune time. While the museum's collection of insects is more than 50 per cent beetles and "the most important in the western hemisphere," according to Furth, it needs a lot of curatorial work. Specifically, Furth wants to curate the F. C. Bowditch collection of chrysomelids, among others. These are now crowded into specimen boxes with ambiguous labelling and with the type specimens the original, irreplaceable specimen, the standard against which all other individuals of a species are compared, mixed in with ordinary specimens.

Furth wants to have at least one tray per species and each type specimen in its own box. The process of sorting, reclassifying, and relabelling, however tedious and lengthy, involves more than curatorial bookkeeping. Furth contends that "collections research is often more important than fieldwork; it's what you base everything else on." Moreover, a collection such as the Bowditch will yield new species, type specimens thought to be lost as well as other undescribed material.

Noting what E. O. Wilson has called the "biodiversity crisis"—the increasing extinction of species, many of which remain undiscovered—Furth says an upgrading of the collections at Harvard is crucial for an accurate account of the already collected species. Without knowing what we already have, it's difficult to calculate the extent of the destruction now going on in the natural world.

While Furth has studied many aspects of the beetle, including the unusual mechanism for jumping used by the flea beetles (Alticinae), some of his more recent focus both in collecting and research involves the plants that beetles feed on. In fact, some of the beetles he studies are so small, that he looks for characteristic plant damage during collecting forays. His own extensive collection of Alticinae from Israel and elsewhere are carefully marked with Latin name, time and place of collection, and, in many cases, the type of plant the particular specimen was feeding on.

The relevance of this approach goes beyond basic science, according to Furth. Because the plants that flea beetles devour are genera specific—species of one genus often feed on specific plants or groups of plants—beetles can provide a good natural agent for biological control.

Born in Cleveland, Ohio, Furth attended Miami University in Oxford, Ohio, and received his Ph. D. from Cornell after working for several years in Israel on the systematics, zoogeography and host plant relationships of the Alticinae. He comes to Harvard from the Peabody Museum of Natural History at Yale.

Wilson Recognized

Edward O. Wilson, the Frank B. Baird Jr. Professor of Science and Curator of Entomology at the MCZ, has recently received two significant accolades.

He was awarded a 1989 Ingersoll Prize, which carries an honorarium of $20,000 and is given to "authors of abiding importance whose works affirm the moral principles of Western Civilization."

In addition, Wilson's *Sociobiology: The New Synthesis*, published in 1975, was recently voted "the most influential book in animal behavior in the last 20 years" by a wide margin of his colleagues in the *Newsletter of the Animal Behavior Society*. A majority of respondents also ranked Wilson's monumental work as the most important book of all time in animal behavior.

Caterpillar Scholar Visiting MCZ

Duncan Reavey, a Kennedy Scholar from York University, England, who is spending this year at the MCZ, has put in a lot of time in the field watching caterpillars. Indeed, last year he spent four months on Skipwith Common, a nature reserve near York, studying in detail the daily habits of the yellow horned moth (*Achlya flavicornis*).

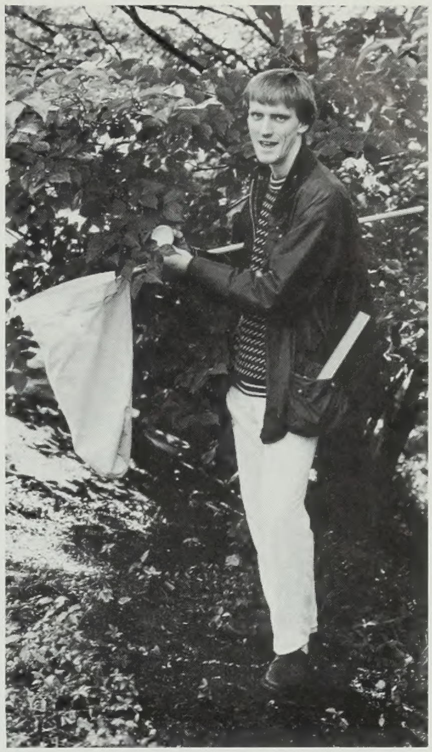
Caterpillars, Reavey has found out, "are not just feeding machines," as naturalists and others have assumed for hundreds of years. Rather, he has found that caterpillars are constantly making decisions as they move about on plants: where to go for food, what leaves to eat, where to rest, etc. For instance, caterpillars tend to be fussy about what leaves they will eat. They prefer new leaves to old, because the former have more nutrients, and they avoid leaves damaged by other caterpillars because such vegetation will have produced defensive chemicals.

Each species, moreover, manifests it own characteristic behavior. *A. flavicornis*, for instance, "twists leaves into little shelters where it sits when not feeding." When it does emerge, it moves as much as a half meter away from its shelter among the complicated leaf system of the birch on which it feeds and still manages to find its way back. Reavey's hunch is that the caterpillar leaves a trail of pheronomes to guide itself back to its shelter. He plans to test this hypothesis next year by obstructing the trail and seeing how the caterpillar reacts.

Reavey finds this kind of field work essential to biology. "All too often this kind of natural history is forgotten; scientists become too interested in models on the computer and experiments in a bottle. There's no substitute for natural history in the field. You get your feet wet and you get bitten by mosquitoes, but so what?"

While here in the Entomology Department, Reavey will study the behavior of newly-hatched caterpillars. What are their decisions the moment they emerge from the egg to march off immediately in search of food, to sit and wait for new buds to burst, or even to "balloon" on air currents from tree to tree till they find one that's acceptable?

In addition, Reavey will be learning Arabic during his year at Harvard, not as a linguistic or literary exercise, but as another tool to use in the field. Not long ago he spent time in the Sudan, working with cotton farmers to control the termites that plague the cotton crops in that part of the world. "It will be a lot easier for me to get input from the farmers, none of whom speak English, if I know something of the language," he says.



Duncan Reavey demonstrates his caterpillar-catching technique.

A graduate of Oxford, Reavey is in his third year of a doctoral program at York.

Birdbrain development studied by Balaban

Evan Balaban, appointed Assistant Professor of Biology as of July 1, will pursue his interest in the correlation between the brain, systems of communication, and social organization in his new MCZ lab. He received his Ph.D. at Rockefeller University and subsequently conducted research at the National Center for Scientific Research, Institute of Embryology in Nogent sur Marne, France.

Operating on the assumption that dissimilarities in the brains of different species of animals lead them to experience things in unique ways, Balaban wants to pinpoint which areas are responsible for specific behavioral differences, and ultimately, by isolating the mechanisms in development that influence brain structure and function, to understand how brains evolve. Balaban's background in music and cultural anthropology plays an important role in his current research interest. During his graduate studies Balaban examined culturally-transmitted vocal variation in birds that learn vocalizations from members of their own species. The only other vertebrates that do this are marine mammals and humans. As in human language, bird songs change over time and distance. As the range of a species expands, population groups further away from each other tend to be less likely to exchange members directly. It follows that these groups would have songs least like each other. However, Balaban discovered that there are bizarre exceptions to this generalization. Often populations living close together have very different songs, and these populations tend not to breed together, indicating that culturally-transmitted songs play a role in defining whom individuals choose to interact with.

Bird songs also contain many features which are shared by all members of one species and which differ from other species. Such

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Taylor

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killing people, and I wondered about why they weren't more careful in restricting access."

Professor Taylor told a black-humor story about his high school chemistry class which suggested that his college interest in the politics of information began a bit earlier. "People were paranoid, building bomb shelters and worrying about the Russians and so forth, and we actually had training in learning how to track and map radioactive sources, and we went out with Geiger counters. We'd be wearing helmets [he gestures to an imaginary helmet with a smile], and we'd stop cars and tell them we were looking for somebody that was smuggling a bomb, and we'd turn up the audio on the calibration mechanism of the Geiger counter, and stick it under the car, and the thing would go click!-click!-click! We'd get quite a reaction from people! But that's when I was made aware of the fact that you did know what these effects were."

Near the end of our conversation Professor Taylor spoke of his son. "In first grade my little boy had a science teacher who really stimulated his curiosity, about rocks, and animals, and machines and how they work—that kind of experience can have an enormous impact by giving you the feeling that you can really understand these things."

It seemed to me that a significant part of Professor Taylor's life in science began with his family, with their persistence in seeing and confronting the reality of humans in severe situations, and continued with his own interest in trying to understand the reality of life-threatening misinformation. His present focus on the realistically functioning whole animal and its confrontation and interaction with a harsh environment seems to continue this theme of striving to see clearly.

There's a two generation pattern of tenacity here: sticking with a different situation until its meaning becomes clear, until the answers to questions are unravelled.

When we'd spoken of the effects of radiation, Taylor commented, "It's only been recently, in the past five or six years, I think, that people have begun to worry about long-term effects. Somehow our system isn't equipped to deal with something that's going to happen twenty years down the road. But we've begun to focus on that now."

New Masters of Dunster House

Karel F. Liem, Henry Bryant Bigelow Professor of Ichthyology in the MCZ, and his wife Hetty have been appointed co-masters of Harvard's Dunster House. "Living with undergraduates helps keep me young," explains Liem as one reason he has assumed this new responsibility.

Balaban

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"species specific" features can be used to discover which brain cells are responsible for species differences in behavior. This is done through a delicate technical feat: switching brain regions between quail and chicken embryos. The resultant chicks sound distinctly quail-like; by transplanting brain cells, behavior can be transplanted as well. In future experiments Balaban hopes to pinpoint more exactly which parts of the brain account for the difference in chick and quail songs. On a larger scale, these tissue transplant experiments can also be used to study brain development. Although the quail and chick cells fuse seamlessly (in fact, five hours after the procedure one cannot tell that a transplant has been performed), the quail cells remain recognizable and distinct under a microscope, and serve as markers to reveal the patterns of cell division and migration that take place as the embryo develops. With this information, in conjunction with future findings regarding which areas of the brain are responsible for specific behavior, Balaban hopes to uncover the mechanisms in development that change brain structure and function and reveal how brains with different behavioral potentialities can come about.

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